

Impact of Climate Change on Indian Agriculture Sector: Food Security, Crop Pattern and Management

Ashok Kadaverugu*, Pratyusha K.**, Machiraju Ramprasad*** and Viswanadh G. K.****

ABSTRACT

This study discusses crops and developmental issues. Short and long-term actions needed for food security are detailed. Telangana is examined in this context. Our findings conclude that crop selection during seasons and the pattern, combination cropping are the most relevant actions directly linked to ensure Sustainable Development Goals. In Year of Millets, there should be should shift gradually from Rice to Mil-lets, which is needed for overall health and economy. Edible oils, Fresh fruits etc are still the major imports. The diets should change for SDG. For example, green peas, seeds of beans, horse gram have to be used in the place of imported pulses. Many nations facing acute financial and food crisis .Bread became luxury for common men. On the other hand India has surplus food grains. New companies for barter trade are need of the hour.

Keywords: Climate change; Crop pattern; Food security; Millets; SDGs.

1.0 Introduction

Even after the remarkable progress achieved during the last sixty years in reducing world hunger, by different practices such as mid-day meals in Indian schools, highly subsidized rice/wheat through fair price shops, the hunger is not eliminated. UN estimated 821 million people are chronically under-nourished as on 2017, as a direct consequence of droughts, environmental degradation and the biodiversity loss. About 90 million children under 5 years of age are dangerously underweight. Two billion people around the world lack the essential micro nutrients they need to survive. At the same time, it is noticed that 500 million people are obese (FAO, 2015). To satisfy these growing demands driven due to population growth and dietary changes, food production has to be increased at least by a whopping 60% by 2050.

*Corresponding author; HOD Civil Engineering, Department of Technical Education, Government Polytechnic, Nalgonda, Telangana, India (E-mail: ashokgpw@gmail.com)

**Faculty in Management, Department of Management, CDC, Hanamkonda, Telangana, India (E-mail: pratyusha2416@gmail.com)

***Principal, Department of Technical Education, Government Polytechnic, Koratla, Telangana, India (E-mail: ramprasadhmes@gmail.com)

****Senior Professor, Department of Civil Engineering, JNTU, Hyderabad, Telangana, India, India (E-mail: kasi.gorthi@gmail.com)

However, in Indian context, the Right to Food a guaranteed Fundamental Right which is mandatory by the constitutional remedy available under Article 32 of the Constitution. Through the National Food Security Act, Government of India enacted in 2013 for providing food and nutritional and health security for all humans, by ensuring access to sufficient quantity of good quality food at a very affordable price to people to live a dignity life. But, due to the impending climate variability, ensuring food security in India is not quite stable as estimated. Climate change has been the primary reason for the food shortage across the globe. Despite the industrialization, mechanization, globalization and digitization, food security affected by the climate variability is not controllable. Here it is apt to cite a quote “Nature has given enough for everybody’s needs but not for anybody’s greed.

For all the poor people, modifying to the climate variability vis-a-vis food security, go simultaneously. A paradigm shift in the farming and food systems which are resilient and adaptable to the climate changes, more productive, and more sustainable with reduced labor costs to eliminate hunger and malnutrition is required. It is also essential to examine and balance the distribution of the food, to control the two extremes of obese and malnutrition and to inculcate healthy dietary habits to keep the menace of the diabetes under control. FAO of UN, has critically examined in 2015 and recommended to mitigate the climate change so as to keep it, at the standards, where it is still possible, so as to ensure and to provide food security without malnutrition. This is achieved only with the changes in agriculture crop pattern, genome modification of seeds to resist the climate changes, with rise in global temperature and various new varieties of pest threat. Talon and Gmitter (2008) have observed the need of innovative breeding strategies and a better efficient use of genetic resources to increase resistance to climate change to increase the yield. In this exploratory paper, we aimed to study the impact of climate change essentially on Indian farming (the world’s highest populous country) sector vis-à-vis the changes proposed in the crop pattern so as to make the country food secure, safe with reduced pesticide residues, reduce imports, increase exports by augmenting the agriculture infrastructure coupled with satellite technology and effective policy planning.

Recent climate change and climate vulnerability studies show that land degradation, high-intensity rainfall in short duration, pluvial floods, heat waves, extreme temperatures, cyclones, water availability, shortage in farm labor, monkeys menace, lack of technological implementations and drought are major factors which are dramatically affecting the agriculture and allied sectors (Palanisamy, 2019; Your and Arora, 2020; Chandio et al., 2022; Subba Rao et al., 2022; Tanti et al., 2022).

Ensuring Sustainable development goals (SDGs) such as Zero hunger (goal-2), Good health and well-being (goal-3) with balanced diet, Responsible consumption and production (goal-12), and No poverty (goal-1) are all related to the agriculture sector and to the climate change. To achieve these SDGs, every country should engage in strategic planning of its agriculture policy and as agriculture is state subject as per Indian constitution, it is proposed to study the policy at state level, taking the newly formed state of Telangana which is the

pioneer in introducing the changes. Even though it was observed by the United Nations (UN) that the undernourished people decreased globally, by almost half in the last two decades owing to increase in economy and in farm productivity, still few developing countries in Africa and South America are facing severe food insecurity. The SDGs aim to end all types of hunger and malnutrition by 2030, assuring all children should have adequate and nutritious food throughout the year, by promoting sustainable farm practices, supporting small-scale and medium scale farmers and providing equal access to the cultivable land, production technology, and crop loans facilities and to the agricultural markets. International cooperation is the hour of need to ensure sufficient investment in agriculture infrastructure and technology to improve the productivity, towards achieving zero hunger goal (UNDP). Agriculture infrastructure includes indoor farming, green houses, hydro phonics etc. in view of monkeys menace, these practices must be popularized which may require large investments.

India, the largest subcontinent is no exception to the problem, comprising of 28 states, with varying agri climatic conditions having its own diversity in all aspects – culture, religion, food habits. All the problems which were on the globe, appear in a single country, the India. The rich obese and the under privileged and undernourished, and the floods and droughts, peak and extreme temperatures, urban conglomerations and rural villages coexist simultaneously. India, being the largest country, still relies on imports for 70 percent of its edible oil consumption, is of grave concern, when there is a possibility of sustainable achievement. The availability of agricultural land, irrigation facilities, human capital and above all the need for production is there. The edible oil imports may go down if migration of farm labor is eased. We can see large coconut farms in Kerala and other coastal belts. But due to shortage of labor, full potential yield from those farms is not there. The monkeys menace discouraging ground nut, sun flower cultivation. Though imports of edible oils is on rise, there are few commodities that have significant positive growth in exports are wheat, Soya meal, Cereals, Rice, Spices, Cotton, Sugar, Vegetable fresh and processed and also Alcoholic Beverages. Research on alcoholic liquor production is also not up to the mark. As India is capable of producing sugarcane in 48000 km² area (Prakash Gowda et al., 2022), which is the most efficient bioenergy crop (Yin et al., 2023) there is lot of scope for liquor manufacturing large scale production can also be planned. Around 360 million metric tons of cereals and 46 million metric tons of pulses/year will be needed to feed India's rising population by 2050 as per "Vision 2050", published by the National Centre for Agricultural Economics and Policy Research (2013).

As a result of excessive and uncontrolled soil erosion, deforestation, unsustainable agricultural methods – indiscriminate and over usage of chemical fertilizers and pesticides due to non application of farm yard manure (FYM) and indiscriminate extraction of groundwater, apart from urbanization, about 29 percent of the India's total geographical area is being degraded (Desertification and Land Degradation Atlas of India June, 2016). It is also relevant to mention that India is also vulnerable to all types of disasters including earthquakes, floods, cyclones, pest attacks and droughts. National Agriculture Disaster Management Plan (NADMP) for the Ministry of Agriculture and Farmers Welfare has been

visualized with the objective of strengthening resilience of farmers to cope with disasters and climate variability. Indian agriculture is subjected to huge economic losses. (Roadmap, NIDM). National Disaster Management Policy, 2009 has been framed keeping the objectives of promoting the culture of preparedness including prevention, and resilience at all of the levels by imparting knowledge, innovation, training and education and through encouragement of mitigation measures based on technology coupled with wisdom, marketing strategies and environmental sustainability.

With the enormous growth in the population in India, it has become the most populous country of the world, surpassing the China, which has reduced its population growth rate by about half from 2% in 1973 to 1.1% in 1983 (<https://www.bbc.com/news/world-asia-india-63957562>). This accelerates the need of food security and urgency in bringing the policy changes to achieve the same. East Asian countries such as Malaysia, Thailand, Korea, and Taiwan, which commenced population control programs later than India, successfully achieved lower fertility levels, reduced infant mortality rates, increased incomes and improved human development much earlier than India. Of course now India has largest population of youth. If planned properly India can become the world work force.

Even today, majority of agriculture production in India is rain-fed, except very few proportion of crop area that is irrigated by various means. Climate change is making monsoons and rainfall unpredictable in terms of intensity, duration and timing. As a result, rain-fed cultivation is affected. This effect is severe in South Asia including India. Total cereal production will decrease and causes food insecurity and hence leads to loss of livelihood. The rising levels of the sea will damage nursery areas for fisheries. In Telangana rural tanks became fish breeders in the recent past which is good sign for food security. Paddy (Rice crop) farms may also be planned as fish breeders. Agricultural land will decrease and the available land may not continue to be suitable for the present crops any more. Farmers have to explore the various options of changing crops depending on changing weather, which have to be aided properly by institutional support. (<https://www.indiawaterportal.org>). About 8.5% of the gross cropped area suffered loss in the floods of 2017 to 2019, which is very high. The intensity of floods and extent has been on increase in the country, due to excess rainfall combined with extremely heavy precipitation in a short span of time (DTE, 2019) About 18% of India's GDP and 50% of country's human capital is in the agriculture sector. This indicates the need of attention and focus on the agriculture infrastructure, without which the development in other sectors cannot be visioned or achieved, especially in India (Despande, 2017).

To meet the challenge of sustaining food production in the wake of changing climate, Government of India launched a flagship network project 'National Innovations in Climate Resilient Agriculture' (NICRA) in 2011, which is a multi-disciplinary and multi-institutional network project. The objectives of NICRA project include to strengthen the capacity of scientists and other stakeholders in climate resilient agriculture, and to draw policy guidelines for adoption of resilience enhancing technologies (NICRA,2011). NICRA is being

implemented in farmer participatory mode in 151 climatically most vulnerable districts of the India. The interventions covered by NICRA in natural resource management, crop pattern – for example advancement of planting dates of rabi crops where heat stress is expected, suggesting location specific inter-cropping system, advising climate change adaptation strategy for livestock and fisheries in respect of fodder production and storage. It also introduced institutional interventions, introduced climate literacy. Within six years of its inception, about 10,000 capacity building programs were organized to benefit 4.2 lakh stakeholders across India. The cropping season, its time period and various crops grown in the seasons and the Indian states, in which this is applicable, is given below in Table 1.

Table 1: Cropping Seasons and Crops Grown in India

Cropping Season	Duration	Crops Grown	States
Rabi Season	Sown during: October-December Harvested during: April-June	Wheat, Peas, Barley, Mustard, Grams,	Haryana, Punjab, , Himachal Pradesh, Uttarakhand and Uttar Pradesh, Jammu and Kashmir
Kharif Season	Sown during: June-July Harvested during: September-October	Rice, maize, jowar, bajra, tur, cotton, moong, urad, jute, groundnut, soybean	Andhra Pradesh Assam, West Bengal, Telangana, Tamil Nadu, Kerala and Maharashtra, Odisha
Zaid Season	between Rabi and Kharif seasons	Seasonal fruits, fodder, vegetables	northern and northwestern states

Source: Based on authors' study

Telangana is a recently formed state in June 2014, with the slogan of Water, Funds and Employment. The so far neglected economy, Irrigation, Power, agriculture and all infrastructural aspects need to be redesigned for its development. Through meticulous planning, strategies, apart from the construction of the Kaleshwaram, which is the largest lift irrigation project in the world, the state government is progressing in overall development including laying of Highways, increasing ayacut with mission Kakateeya and hence agri-products. Even the state went upto bagging awards in Swachha bharat activities. The agricultural and other procedures, which proved successful, to be adopted by the country by modifying to the local situations. To minimize labor costs, paddy nursery bed system is getting modified and seed is sown directly. Telangana State government has attempted to test the soils in large scale. Even the silt from tanks is also tested and then only dumped in to farms.

1.1 Objectives of the study

In this context, the study aimed to address the following objectives:

- To understand the climate change and its effect on agriculture production
- To examine the food security of the country vis-à-vis imports and exports, in agriculture.
- To explore agriculture infrastructure with the technological advancements.

- To explore and recommend various suggestions including paradigm shift in crop pattern so as to achieve SDGs envisaged.
- To explore rural and agro tourism
- To examine the Telangana State of India in detail in the context of the proposal.

2.0 Methodology

In the present study, exploratory method is followed and we analyzed the dynamic scenario of food security impacted due to climate change, food habits of growing population and examined the agricultural crop diversification, considering the Telangana State, India. The study is purely based on secondary data obtained through literature review of various official documents published, on the topic. The policy documents on agriculture related missions in India and Telangana State and research papers published during the last decade are examined to interpret the current and future agriculture scenario in India and Telangana State. A total of 12 policy documents, and 15 research articles were summarized in the study. Agricultural experience of the authors, interviews with the farmers and land owners, on the issues have been an addition to the discussion. The interdisciplinary approach makes the study, unique and novel in the field. Innovative concepts, suggestions have been incorporated, some of which needs research and discussion, before being implemented.

2.1 Study area

Telangana is a newly formed state in 2014, Telangana, situated in the Deccan Plateau in Indian Peninsula and twelfth-largest state having 114,840 km². The Irrigation water in Telangana is drawn from two semi perennial rivers, with 79% of the Godavari River and 69% of the Krishna River catchment areas. Minor rivers such as the Bhima, the Manjira, the Musi, Munneru, Maneru and about 40000 village tanks are also there. The study area is shown in Figure 1. Total geographical area of Telangana is 1,12,077 km² half of it is gross cropped area.

About 24 per cent is under forests and 7.7 per cent is under other uses. Telangana cultivates various crops including Cotton in 18130 km², Rice in 14190 km², Maize in 6630 km², Pulses in 6110 km² along with Groundnut, Chillies, Sugarcane. About 79% is in Kharif (vaanakaalm panta) and the remaining 21% is cultivated in Rabi (yesangi panta) seasons. Agriculture contributes 13 per cent to the state income and nearly 56 per cent of Telangana population depends on it.

Previously agriculture in Telangana was rain dependent and its distribution. But after Kaleshwaram project, Mission Kakateeya, the farming is partially freed from rain fall. Nursery beds are grown even in midsummer. The influence of South-West monsoon, which contributes 79% is major source of rainfall and is from June to September, Whereas the North-East Monsoon is from October to December. Kaleshwaram, the largest multi-stage lift irrigation Project of the world is built on the Godavari River in Kaleshwaram, Telangana,

India. Based on climatic parameters such as Rainfall, Soils and cropping pattern, the state of 33 districts is broadly divided into three agro-climatic zones, which are shown in Figure 2. Assuming a moderate rain fall for continuously five years or 3 years severe drought, in such situation also Telangana may not be affected much in Agriculture. The agricultural planning for each zone is supported with the research and recommendations of Regional Agricultural Research Stations of ANGRAU setup within each zone.

Figure 1: The Study Area

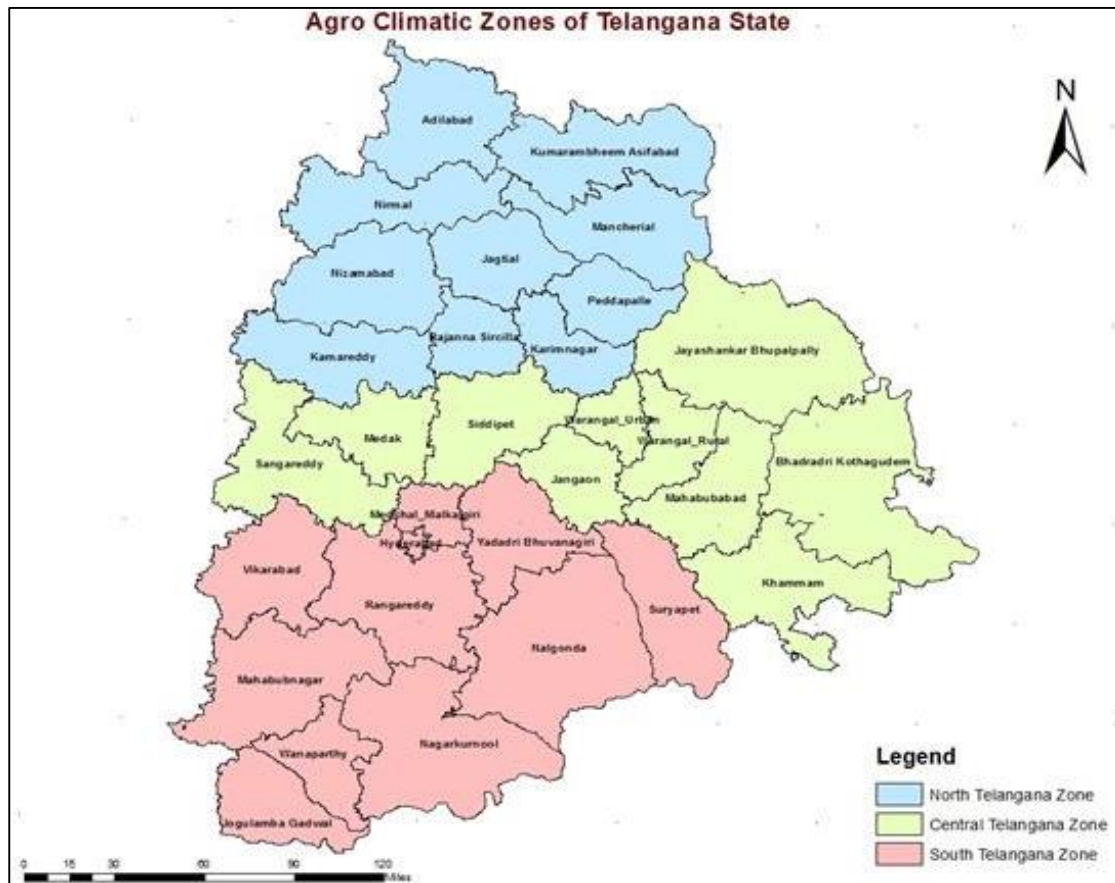


Source: <https://pjtsau.edu.in/agro-climatic-zones.html>

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Figure 2: Agro-climatic Zones of Telangana



Source: <https://pjtsau.edu.in/agro-climatic-zones.html>

3.0 Discussion

According to Directorate of Economics and Statistics, Government of Telangana, cropping pattern was shifted since 1980 to non-food crops in Telangana state. From 29% non-food crops in 2001-02, now increased upto 47% in 2015-16. Wheat recorded good growth and earnings of export increased from Rs. 425 Crore to Rs. 3283 Crore and other cereals recorded a growth from Rs. 1318 Crore to Rs. 4542 Crore. India has seen a tremendous growth of 727 % in respect of Wheat export and also 132% growth in export of Rice.

Genetically modified (GM) seeds offer resistance to pests and herbicide, there by yield high productivity. While the advantages of GM seeds are more it should be cautious to use them. Genetic engineering should be seen as another discovery which has a lot of potential for developing and developed countries (Batista, R., & Oliveira, M. M. 2009). Sustainable Intensification (SI) as proposed by Pretty (2018) is a system in which agricultural

production is maintained or increased while enhancing environmental outcomes. SI incorporates no more land cultivation and without any additional environmental cost. Such type of systems should be embraced throughout the globe, to achieve SDGs. Zero budget natural farming propagated by Padmasri Subhash Palekar can also be encouraged which minimizes damage to basic ecosystem. Citrus is a very important fruit plant grown throughout the world for its great economic significance and also of tremendous value for nutrition and human well-being (Manuel Talon and Fred G. Gmitter Jr).

CRRRI has developed 105 varieties of rice in India and a suitable selection of rice variety is crucial to yield high production. Here In Telangana mango orchards are in promising number but menace of monkeys is an issue to be addressed. Food processing industries such as mango Jelly and pickle making should be in large scale with least dependence on sun light, as sun light drying is slow and also natural calamities such as sudden rain or gales damage the process. Further under the shade of mango orchards certain crops, fodder, mushroom can be cultivated. Dairy, poultry can also be considered for effective land use. The dung out of such farms, becomes natural manure which minimizes the use of chemical fertilizers and pesticides.

High crop diversification is followed in a major share of agricultural area of Telangana, India. This area is characterized by erratic rainfall and soil health and with a very low level of agricultural intensification. The Mahabubnagar, Rangareddy and Medak, which are close to Hyderabad, are less than 20 degree of diversification. Hyderabad being a metropolitan city requires more varieties of food items which makes these districts to grow different crops. As part of agricultural intensification, drip, sprinkler and AI enabled micro irrigation systems, organic cultivation have great scope in these areas. The three approaches to sustainable intensification of agriculture are improving efficiency, substitution and system redesign (Pretty et al. 2018). Impacts of the climate change in agriculture in Norway has been studied by Uleberg et al. (2014) and noted that, challenges such as increased autumn precipitation unstable winters, more weeds and more diseases, higher temperatures create new opportunities for agriculture in the region. This is to be supported by tailored adaptive strategies and breeding of new plant varieties. Changes in sowing calendar, hydroponics, green houses and crop rotation are some of the adaptive strategies, suggested. Economic incentives to the farmers play in crop choice in the crop rotation.

3.1 Paradigm shift in Culture

Government and Non-Governmental Organisations (NGOs) should make complementary attempts to achieve cultural change through behavioral modification in the farmers in particular and all the people in general. The 'Millet Mission' in India is an example, in this year 2023. The drought-resistant and pest resistant crops are to be promoted encouraging a paradigm shift away from water-intensive Rice and maize, across the country. The inclusion of millet in the Public Distribution System (PDS), and awareness drives, meetings, millet recipes in welfare hostels and other gatherings should be harbinger to change dietary patterns. Distribution of millet recipe books in local and vernacular languages will go

a long way. Fundamental shifts, deviating away from the status-quo are more difficult to implement, due to the resistance to change apart from political sensitivities. To encourage the use of millets, millet flour can be mixed with wheat/rice flour so that people easily adapt for it.

The indiscriminate use of fertilizers, pesticides is causing significant deterioration of soil health affecting the productivity. Using enhanced-efficiency fertilizer can avoid fertilizer-related water pollution by about 60%. Transition to more natural farming practices using domestic waste based manure, composting, while maintaining productivity and food security will be the target for the cultural shift. As water is available throughout the year, to cope up soil health green gram, jeeluga etc may be sown in summer or before sowing of targeted crop. Four decades back, natural manure in the way of green manure, accumulated house hold waste, including cattle dung and other organic waste used to be supplemented as good fertilizer. This reduces the usage of chemical fertilizers, saves energy saving, friendly to the environment and above all sustainable. There is practice of leaving cattle for grazing during summer. This is causing great damage to farmers' because their farms are to be kept idle or provided with perfect fencing. This adds to the investment for the farmer. The state government should take care of cattle grazing. The urbanization and shift in culture, usage of plastics and polythene covers all made it the process extinct from rural areas too and vicious cycle initiated. The World Bank Group's Climate Change Action Plan (2021-2025) is aimed at technological interventions to enhance the crop productivity, improve resilience, and to reduce Greenhouse gases (GHG) emissions. The Action plan helps in avoiding food loss and waste and also control flood and drought risks. Hope the bio-degradable plastics come in near future. FiloPack is bio-degradable, a new product from ITC's Paperboards which is recyclable, compostable paperboards. FiloPack is used to make eco-friendly paper plates and trays.

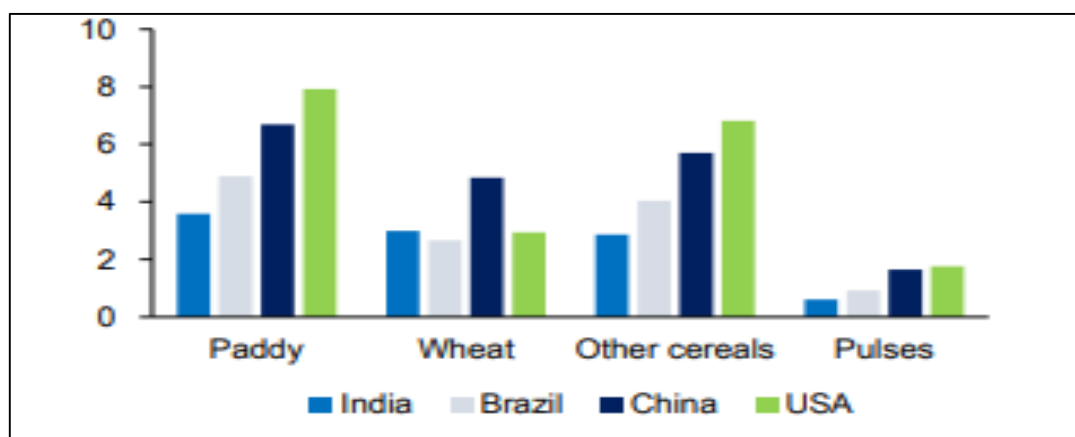
There should be a great change in crop pattern. Instead of Rice crop (Paddy), preference should shift towards millets, pulses, oil seeds, coconut, Palmolive, banana, bamboo, veggies, green banana, sugar cane, root vegetable crops, fodder etc. This shift brings a healthy change of reducing imports burden of oils, pulses and also use of water. Millets so produced also to be distributed to social welfare hostels, fair price shops etc. fodders production should be helpful in live stock and dairy. This rise in dairy products can be meant as buffer to cater to the hunger needs in crisis and also can be exported to the needy countries where intense hunger prevails. Further the live stocks so produced act as promoters of soil health and is step towards organic farming.

Stringent organic farming certification may not be viable but a good soil health and reduced pesticide may make the products partially organic. In veggies if we think of pumpkin, ash gourd, green banana, fruit banana, jack fruit, organic production is quite possible because they naturally come with good soil health. For marketing these vegetable and encourage usage, the culture and food festivals can be a good platform. The urban population naturally moves to villages during Dasara and Pongal times. Those occasions must be used as publicity

and marketing time. Some more rural festivals may be promoted and these rural festivals must be elevated as international events with many new folk singers, music artists, food makers, dress designers. Village water tanks with reasonably good tank bund attractions, “palleprakruthivanams”, rural nurseries, now a days, a government policy in each and every village, can be another special attraction of visit. Soft ware, IT must work out to plans for effective marketing. Even we can think of Rural Goshalas with accommodation can be place of attraction for some people. All this is possible with good law and order. Another issue to be addressed is labor problem. There can be out sourcing agencies to bring labor from CG,UP,Bihar, WB,Jharkhad, UK etc. Where ever there is great hunger, it can be a source of labor for us and we will be give solutions to resolve hunger.

In India, the net yield of the crops is very low, as seen from the figure 3 (Jennifer Burney and V. Ramanathan, 2014). Yield of any rice variety depends on its optimum time of sowing and harvesting. A thought to be made to go for government nurseries for paddy because of assured quality of seed and effective nursing with scientific and controlled methods. This also provides employment in rural areas.

Figure 3: Yield in Different Countries in Tonnes/Ha



Source: Food and Agriculture Organization of the United Nations.

Solid waste management and air pollutants will affect the vegetation near to the source of its emission and surrounding urban centres, but depending on the local meteorology -wind velocity, it is transported and affect the nearby agriculturally rich rural areas, damaging the crops (Richa rai et al. 2014). The air pollutants cause some deleterious effects on plants metabolism owing to their oxidizing potential.

3.2 Successful practices in the study area

The popular rice varieties suitable to different ecologies are: Vandana, (RR 167-982) tolerance to drought, seasonal resistant Satabdi (CR 146-7027-224), Satyakrishna (CR AC

2221-43) suitable for shallow low land irrigated area, Phalguni (CR Dhan 801) has slender grains and high yield of 5 to 6 tonne per hectare, Swarna Sub-1 (CR AC 2539-1) which can tolerate complete submergence for 14 days suitable for flash flooded coastal regions, Sarala (CR 260-77) which tolerates submergence of half meter depth of water, Durga (CR 683-123) tolerates submergence of one meter depth of water (https://crri.icar.gov.in/popular_var.pdf). RNR 15048 the Telangana sona, which can be raised in both kharif and rabi seasons in a short duration of about 125 days has low Glycemic Index (GI) of 51.5 percentage compared to other varieties (the Hindu 26th April, 2016). Few high yielding, pest and disease resistant rice varieties have been released by the Regional Agricultural Research Station (RARS) Warangal since 1974. They are Kakatiya, Surekha, Pothana, and Divya.

Further in 1990s Erramallelu, Kavya, Bhadrakali, Orugallu, Shiva, Keshava, are released. Now Varalu, Warangal Samba and Warangal sannalu and Ramappa, Siddhi, and Sheethal are also released which are pest resistant and high yielding rice varieties, successfully grown in this north agro climatic region of Telangana. For getting more income, Baasumathi (SCENTED RICE) is to be grown and marketed by farmers. having tie up with hotels, restaurants, caterers and hostels. Telangana government is further emphasizing on multidisciplinary science and traditional based methodologies – natural resource management, crop production, crop protection, farm mechanization and value addition etc. which optimize resource utilization simultaneously which are cost effective to ensure good returns to farmers. Pigeonpea, bajra and ragi were found better than maize on rainfed Alfisols in Medak district of Telangana. Intercropping for example sugarcane with coriander/Clusterbean/Bhendi gave better returns in North Telangana zone. Crop rotation of Soyabeen-Maize-soyabeen-maize showed maximum yield. Zero tillage maize is being adopted which resulted in soil fertility. Technology of drip irrigation and fertigation resulted in augmenting the tomato productivity. Green house farming is also promising for some crops especially for vegetables

Dharani in Telangana, which is introduced as land reforms and land records data base, is impacting positively on the farmers, land owners, for a transparent land transfer system. The Raitubandu, meaning relative of farmer, scheme, is proved to be very effective and should achieve good results, if implemented with some good initiatives. Here considerable land is still in the name of erstwhile land lords. The govt of Telangana is expected to work out a method for such land transfer to real owners of today. The koulu system (farm land lease) is also to be modified. The koulu raithulu (farmers who took land on lease) must be given some incentives without causing loss to land owners. The government must act as liaison between land owners and farmers on lease. This assurance certainly enhances the productivity. Further crop loans should be much more stream lined and be given in time. Banks and government must come forward to assist enthusiastic farmers by giving loans in time. Repayment system also should be such that either banks or farmers are not badly affected. If the farmers pay back loan in time maximum incentives may be given. The government and private employees should be encouraged to take up farming as alternate

source of income. E-Bhoomi project in Karnataka type of land management schemes are good measures for small and marginal farmers, to keep abreast in using technology in agriculture industry.

As mono cropping creates biotic and abiotic stress on soil, crop diversification is better solution for sustainability, which should be understood well by the local farmers for its successful implementation. Crop diversification changes mainly due to availability of irrigation facilities such as availability of fertilizers, lift irrigation facilities, fertile soil, adoption of fertilizers and mechanization of agriculture etc. S.C Batia crop diversification method can be better followed. Crop pattern changes, in low diversified areas leads to environmental problems such as groundwater depletion, soil fertility loss, and even causes water logging. Hence high diversification needs to be encouraged (Kamaraju et al.2017). Crop substitution and shift are also suggested. For example, the growing of rice in high water table areas substituting with the oilseeds, cotton and pulses worked well. In Cotton, maize is a good example. This also helps in other way. Even if one crop fails, farmer may get benefit in other. Similarly in ground nut, red gram may work out well. Even in paddy, there is scope for red gram along the boarder bunds. State Government can control the crop pattern according to the demand and supply, plant and soil health, to suit to the climate variability and pollution levels and even suggest the variety of seeds to be used, to get more yield.

4.0 Implications of the Study

It is observed that, if the cash crops like coconut, pulses, oil seeds are cultivated in combination with regular crops such as paddy, then India can reduce the burden of imports upto some extent. Gradually, India will be in a position to export these cash crops. The reduced paddy should be replaced by millets. The economical implications involved, reducing imports thus making India self sustainable and even increasing the imports to get foreign exchange etc. are to be critically examined for the benefit of multiple stakeholders. The dietary culture should gradually shift India's staple food of rice, wheat to millets and other healthy grains. This would also help control the deteriorating health of youth in particular and all in general.

Short term mitigation measures include strengthening the Public distribution system PDS with the reduced staple foods, including healthy millets and ensuring minimum calorie food supply to all the citizens. Intelligent use of fertilizers and limited use of pesticides, ecofriendly practices in packing and transportation, distribution system should be encouraged. Menace of rats, is the major cause for net yield of crops, during harvesting as well as during preservation of grains in godowns, which can be controlled by following appropriate methods. Pythons are expected to be rat eaters. Since Pythons cannot cause much serious problems for human beings they should not be killed any more so as to control the problem of rats. Crop diversification, crop rotation based on recent research by ICAR through NICRA will certainly improve soil fertility and increase yield per hectare. The farmers should be educated by involving NGOs and various governmental departments, for following such good

practices in agriculture management. Rice-Wheat Crop Manager (RWCM) is developed by IRRI and is an information and communications technology (ICT) oriented web-based decision-making tool which facilitates irrigated and rainfed rice farmers with the personalized crop management recommendation for increasing rice production and also income (Mishra, A., & Sharma, S. 2022).

Long term mitigation measures, such as combined cropping of various food and cash crops, fodder crops and food crops, so as to increase the country's livestock and milk production. Rural and Cultural tourism should be created and marketed by the government. The rural cultivation methods, farm houses and recreation facilities to be created. These facilities help the busy, work stressed employees and business persons by way of compulsory leave travel or voluntary tours, to regain health and recreate for some time, thereby energized. Yoga and music camps, promoting folk arts in these rural areas, will go a long way, in achieving the health to all. Redistribution of national agricultural land to all the citizens, will be a gigantic task, thereby land ownership increases the yield instead of farmers working as labor. The greenery development programs make India restore the climate to the normal and thus rainfall prediction will be appropriate and accurate, which is main cause for yield loss in almost all the crops. Barren land should be identified and brought under cultivation of crops, which were so far imported from other countries. Oil seeds production is much less in India and need is ever increasing. These vegetable oil seeds should be self sufficient, so as to make the country developed. The agriculture should shift its focus duly reducing the paddy and making new area irrigated. The flash floods should be well harnessed and utilized for the irrigation by apt methods and each and every water drop should be used to its fullest level. The castor oil which is not fit for edible may be made edible by appropriate processing by making it safe, which certainly reduces the import of edible oils to India..

The preservation of culture and tradition with updated technology may work out to market rural crops and talent. For ex Dasara or Bathukamma can be celebrated attracting urban people from within and outside the country. This helps promote Rural and cultural tourism and enables some employment and revenue to the state. These festive and celebrations are occasions to involve and encourages the folk dance composers, lyric writers, singers, folk music composers and musicians, video graphers etc. It also results in de migration from the urban centers, which is one of the causes of climate change. This can be an occasion to market rural farm products. Credit for inputs, seeds, fertilizers, and chemicals, may be given if farmers explicitly or implicitly agree to cropping patterns or only for certain crops, prescribed by the government on the basis of agricultural research (Fawaz M. Shousha, 1997). It is concluded that, interdisciplinary approach is required to achieve the SDGs through climate resilient agriculture, practicing sustainable and eco-friendly methods in India and other developing countries, duly bringing change in the farmers through supportive mechanism and proper education and training and achieving a cultural change on par with climate variability, for survival of the mankind.

Last but not least, model agro/horticulture farms are to be developed in different parts of the country so as to mobilize people to adapt new and sustainable practices. For this all peoples representatives should take initiative.. The agriculture/horticulture/ dairy graduates may be encouraged for this work. Their success becomes success of society.

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